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Far-Infrared Spectroscopy of Interplanetary Dust Particles, Circumstellar Silicate Analogs, and Aerogel: A Prelude to STARDUST Samples

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Beamline(s): U4IR

Introduction: Infrared (IR) spectroscopy is the primary means of remote mineralogical analysis of materials outside our solar system. The nature and properties of circumstellar grains are inferred from spectral comparisons between astronomical observations and laboratory data from natural and synthetic materials. The Infrared Space Observatory (ISO) obtained IR spectra from numerous astrophysical objects over a wide spectral range (out to 50 cm^{-1}) where crystalline silicates and other phases have distinct features. Here we report on FTIR measurements of interplanetary dust particles (IDPs), silicate analogs, and silicates in aerogel that encompass much of the spectral range covered by ISO (~650 to 70 cm^{-1}). The aerogel measurements are very important because samples of comet dust will be collected in aerogel and returned to Earth for analysis by the STARDUST mission in January of 2006

Methods and Materials: Fourier transform infrared (FTIR) measurements of the samples were obtained using a modified Nicolet Irus FTIR instrument (Beamline U4IR) at the National Synchrotron Light Source at Brookhaven National Lab. The IDP sample (~20 μm in dia.) and silicate analogs were mounted on thin Formvar substrates for the FTIR measurements, while the aerogel samples were self-supporting.

Results and Discussion: Figure 1 compares the IR spectra of an anhydrous IDP (L2005*A4) with spectra from forsterite (Mg_2SiO_4) and clinoenstatite ($MgSiO_3$) standards. Simple inspection of the IDP spectrum shows that both forsterite and clinoenstatite are present in the IDP. FTIR spectra of individual 20 μm forsterite (Mg_2SiO_4) grains in aerogel are compromised somewhat by the strong Si-O bending vibration from the aerogel substrate, although there are "windows of opportunity" both above and below the aerogel feature where forsterite and enstatite ($MgSiO_3$) have diagnostic bands. For example, the strong 33 μm band in forsterite is easily detected even in thick (>100 μm) slabs of aerogel. The long wavelength bands in olivines and pyroxenes are not only diagnostic for the crystalline structure that is present, but can also be used for compositional analysis (e.g. Mg/Fe ratio). The preliminary results demonstrate that it is possible to obtain mineralogical information on small particles in aerogel. Far-IR spectra of STARDUST samples would provide a fast, non-destructive technique for in situ mineralogical characterization for these important samples prior to other analysis techniques.

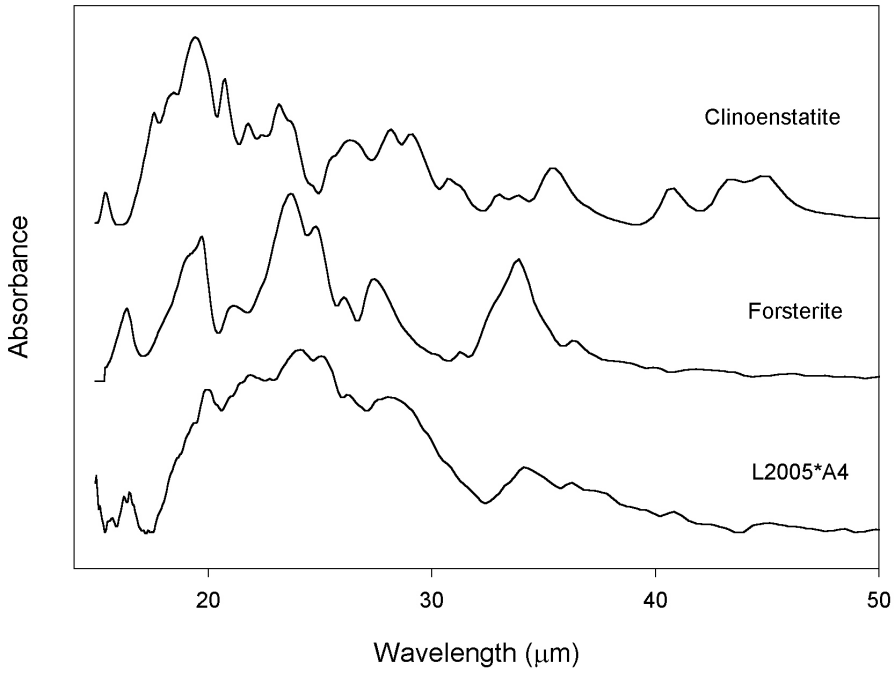

Figure 1. FTIR spectra of IDP L2005*A3 compared to standard spectra of forsterite and clinoenstatite.